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Effect of Methacrylate-based Resin Cements on Tensile Bond Strength of Zirconia Copings on Zirconia Abutments

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Abstract

Purpose: The purpose of this study was to compare the retention of zirconia copings cemented onto zirconia implant abutments using four methacrylate-based resin cements and a temporary cement.

Materials and Methods: Fifty zirconia copings (Cercon Base) and 10 zirconia abutments (Procera Esthetic Abutments) were fabricated and cemented using four methacrylate-based resin cements and one temporary cement (n = 10). All copings were thermal cycled and the tensile bond strength of the copings was recorded using universal testing machine. One-way analysis of variance (ANOVA) and Tamhane's T2 tests were used for statistical analysis.

Results: Retention values of different cements presented significant differences ($P < 0.01$). The methacrylate-based resin cements [Premier: 127,95 (± 19,18), Dentotemp: 110 (± 15,48), Cem-implant: 70,38 (± 12,11), Improv: 69,64 (± 16,63)] had more retention than the temporary cement [Tempbond:36,92 (±6,2)].With a higher percentage (78%), cement failure occurred at the cement/abutment interface and the cement remained mostly within the zirconia coping.

Conclusion: The cement type may have an influence on the retention of zirconia copings cemented onto zirconia implant abutments. The ranking of the methacrylate-based resin cements used, may direct the cement preference of a clinician in terms of providing desired retention.

Keywords

Methacrylate-based cement; Tensile bond strength; Zirconia; Abutment; Coping

Introduction

Zirconia ceramics have been considered among the most promising restorative materials, because of its advantageous physical and mechanical properties [1]. With the introduction of yttria-stabilized tetragonal zirconia polycrystal (Y-TZP), zirconia has been extensively used for the fabrication of implant-supported esthetic full veneer restorations [2]. Today, as an alternative to titanium abutments, implant manufacturers recommend the use of zirconia abutments for better esthetic results in single anterior implant-supported restorations. Zirconia abutments can be either prefabricated or customly prepared in the dental laboratory by the technician or by CAD/CAM [3].

The advantages of zirconia abutments when compared to titanium were reported as less mucosal discoloration, less adhesion of bacteria and low cytotoxicity in human gingival fibroblasts [4-6]. Regardless of the clinical success reported for zirconia abutments in anterior and premolar regions, fracture of the abutments has been reported [7].

Implant supported fixed restorations can either be screw or cement-retained. The major advantage of screw-retained restorations over cement-retained restorations is retrievability which enables to interfere complications associated with abutment or superstructure [8]. In order to overcome retrievability problem in cement-retained implant supported restorations, temporary cementation with conventional temporary cements is a common approach. The temporary cements produced for tooth borne fixed restorations dissolve in a relatively short period of clinical use which causes a decrease in mechanical retention, microbial proliferation and malodor in cement space [9].

Temporary cements with acrylic resin additives designed for long-term temporary cementation of implant supported restorations have been introduced to the market [9]. Those products provide strong enough retention, but still allow the restorations to be easily removed without damage if required. To authors best knowledge, they have not been specifically named after or classified as a subgroup in cement classification yet. Even though they incorporate favorable properties of temporary and permanent cements

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their performance has not been thoroughly studied as a new group of cements. Therefore, evaluation of the tensile bond strength of methacrylate-based resin cements when used for cementation of zirconia copings onto zirconia implant abutments may be valuable.

The null hypothesis of this study was that there are no significant differences in retention of zirconia copings when cemented with different methacrylate-based resin cements onto zirconia implant abutments.

Materıals and Methods

Ten zirconia abutments in 7.6 mm height and 6° axial taper (Procera Esthetic Abutment Nobel Replace RP, Nobel Biocare, Göteborg, Sweden) with 10 implant analogs (Implant Replica Nobel Replace RP, Nobel Biocare) were embedded into auto polymerizing acrylic resin blocks (Meliodent, Bayer Dental, Newburg, Germany) (Figure 1).

Esthetic Abutments were attached to their implant analogs with a 35Ncm torque by using a torque control device and scanned (Cercon Eye, DeguDent GmbH, Hanau, Germany). Fifty zirconia oxide copings (Cercon Base, DeguDent GmbH) with an occlusal loop and 20 µm cement space were fabricated by CAD/CAM machine (Cercon Brain, DeguDent GmbH). The copings were sintered (Cercon Heat, DeguDent GmbH) at 1350°C for 6 h. The accuracy of the zirconia copings were checked using a silicon disclosing medium (Fit Checker, GC Co., Tokyo, Japan) and adjusted onto the individual implant abutments. The inner surface of the copings were air abraded with 110 µm aluminum oxide particles for 10 s and ultrasonically cleaned in 96% isopropyl alcohol for 5 min [10].

Four methacrylate-based resin cements and one temporary cement were evaluated in this study (n=10). The brand names, types and manufacturers of the cements used in this study are listed in Table 1. The abutment screw holes were filled with a cotton pellet and light polymerized temporary filling material (Clip, Voco, Cuxhaven, Germany). The cements were dispensed according to the manufacturer's recommendations, and applied to the fitting surface of the copings. Each coping was placed with finger pressure for 5 seconds. The specimens were then subjected to a 5 kg load for 10 minutes. Excess cement was removed using a scaler. Mixing and cementing procedures were performed at room temperature (24 ± 2° C) by the same investigator. Specimens were stored in deionized water at 37° C for 24 h and thermal cycled for 5000 cycles between 5 and 55°C with a 30s dwell time [10]. After thermal cycling, each assembly was attached to a universal testing machine (Autograph AG-X, Shimadzu Corp., Kyoto, Japan) to apply an uniaxial tensile force with a crosshead speed of 5 mm/min [10] (Figure 2). The mean tensile bond strength values in Newtons were recorded. The modes of cement failures [(A) cement remained in the intaglio surface of the crown, (B) cement remained on both crown and abutment surfaces, and (C) cement remained on the abutment surface] were also evaluated.

Before each pull-out, the abutment surfaces were steam cleaned, dried, and prepared for recementation.

Statistical analysis

The data obtained in this study was assessed using IBM SPSS 22 program (Statistical Package for Social Sciences) (SPSS Inc, an IBM Co., Somers, NY). Conformity of the parameters was assessed by the Kolmogorov–Smirnov test and it was determined that the parameters conformed to a normal distribution. For the intergroup comparisons of parameters, one-way Analysis of Variance (ANOVA) test was used. Since the variances of groups were non-homogeneous, Tamhane's T2 test was used for the determination of the group causing a difference. Significance was evaluated at a level of 0.05.

Results

The mean tensile bond strength values and standard deviations for the tested cements were shown in Figure 3 and Table 2. A statistically significant difference among the mean values of the cements was detected ($P < 0.01$). The Premier group presented the highest tensile bond strength where the Tempbond group presented the lowest tensile bond strength. In particular, Tamhane's T2 test indicated significantly higher tensile bond strength values for Premier group than Cem-Implant, Improv and Tempbond groups ($P < 0.01$). DentoTemp group presented significantly higher tensile

Figure 1: Implant assembly embedded in acrylic resinand crown coping with an occlusal loop.

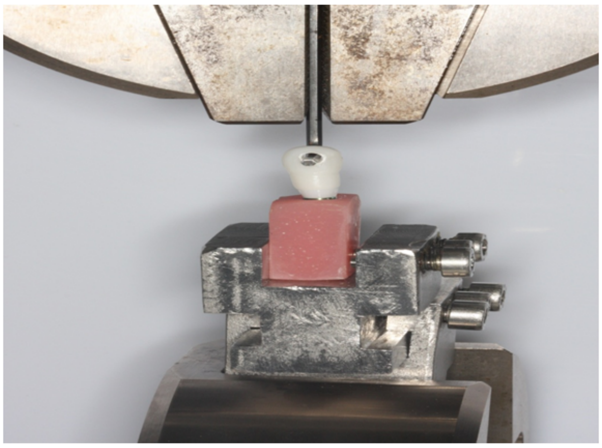

Figure 2: Specimen fixed to the universal testing machine for uniaxial tensile testing.

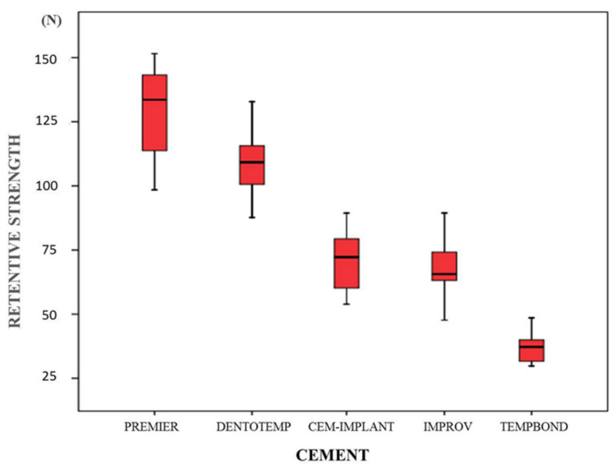

Figure 3: Graph of mean tensile bond strength values and standard deviation of the cements.

Cement name	Manufacturer's description	Manufacturer
Premier Implant Cement	Non-eugenol temporary cement for implant-retained crowns	Premier Dental Products, Plymouth Meeting, PA
DentoTemp	Non-eugenol temporary cement for implant-retained crowns	Itena, Paris, France
Cem-Implant	Non-eugenol acrylic-urethane polymer based temporary cement for implant luting	BJM Laboratories Silmet Ltd, Or-Yehuda, Israel
ImProv	Eugenol-free acrylic resin based provisional implant cement	Alvelogro Inc., Snoqualmie, WA
TempBond NE	Zinc oxide non eugenol provisional cement	Kerr Corporation, Orange, CA

Table 1: Cements used in this study

	Retentive strength	Post Hoc
Cement	**Mean ± SD**	**Tamhane's T2**
[1]Premier	127.95±19.18	1 > 3-4-5**
[2]DentoTemp	110±15.48	2 > 3-4-5**
[3]Cem-Implant	70.38±12.11	3 > 5**
[4]ImProv	69.64±16.63	4 > 5**
[5]TempBond NE	36.92±6.2	
P	**0.001****	

Table 2: Mean tensile bond strength values and standard deviation (SD) of the cements tested.

One way ANOVA Test: ** P < *0.01*

bond strength values than Cem-Implant, Improv and TempBond groups ($P < 0.01$). The tensile bond strength values for Cem-Implant and Improv groups were significantly higher than Tempbond group ($P < 0.01$). The difference between the tensile bond strength values of Premier and Dentotemp groups ($P > 0.05$) and, Cem-Implant and Improv groups ($P > 0.05$) was statistically insignificant.

With regard to the failure modes, for 78% of the implant assemblies cement remained in the intaglio surface of the copings. For 14% of the assemblies, cement remained on both coping and abutment surfaces whereas for 8%, cement completely remained on the abutment surface. The failure modes of the cements and percentages were presented in Table 3.

Discussion

The tensile bond strength of methacrylate-based resin cements when used for cementation of zirconia copings onto zirconia implant abutments has been evaluated in this study. Various luting agents designed specifically for implant supported restorations are being introduced to the market. Those materials were described as semi-permanent cements in literature but their exact classification and criteria of selection is not clear [11]. They are mostly self cure, acrylic urethane-based provisional cements with low viscosity [9]. This study was primarily conducted to compare those cements and a conventional temporary cement, in terms of tensile bond strength. The null hypothesis that there are no significant differences in retention of zirconia copings when cemented with different methacrylate-based resin cements onto zirconia implant abutments was rejected.

The mean tensile bond strength values of the studied cements were ordered follows: Premier > DentoTemp > Cem-implant > Improv > TempBond. Premier presented significantly higher values than the other three methacrylate-based resin cements. The base paste of this product contains 2-hydroxyethylmethacrylate (HEMA) beside methacylate monomers, triethylene glycol dimethacrylate, aliphatic urethane diacrylate resilient oligomer, pigments and stabilizers [12]. HEMA is a methacrylate derivative which is used as a primer on acid-conditioned dentin and has an ability of promoting adhesion. It is also a novel coupling agent used for promotion of resin-zirconia bonding [13,14]. Even though, it was not a clear assumption and it should be validated by microscopic analysis of the cement-coping interface, HEMA consistency in Premier might have contributed to the mechanical retention of zirconia copings. In an in vitro study, the tensile bond strength of five implant cements were compared in cementation of cobalt-chromium copings onto titanium abutments where Premier presented the highest values among implant cements [11].

DentoTemp presented comparable tensile bond strength values to Premier and the difference between two cements was statistically insignificant. The base of this product contains bisphenol A-glycidyl methacrylate (BIS-GMA) as well as multifunctional methacrylate monomers [12]. The addition of an extra low-viscosity bonding resin to cement was reported to allow the cement to spread in a more uniform layer and thus increase the bond strength [15].

Cem-implant and Improv resulted in significantly lower tensile bond strength values, almost half of the Premier and Dentotemp cements (Table 2). The results of the present study were in accordance with Gultekin et al, where Improv presented the lowest tensile bond strength values among all implant cements [11]. On the other hand, the tensile bond strength values of Cem-implant and Improv cements were two times higher than the Tempbond temporary cement.

The use of resin cement, zinc phosphate, glass-ionomer, resin-modified glass ionomer, or zinc polycarboxylate cements were recommended for permanent cementation of implant supported restorations [16,17]. The highest tensile bond strength (127.95±19.18 N) presented in this study was almost half of the value of zinc phosphate cement (258.0 ± 34.4 N) reported in a previous study [18].

In the present study, factors affecting the tensile bond strength such as, cement gap size, abutment height and diameter were standardized. Thereby, it was likely to evaluate the effect cements on retention solely. For shorter abutments, the effect of the tensile bond strength of implant cement should be taken into consideration since the relative axial abutment surface area decreases. Therefore, a more retentive implant cement may contribute to the retention of an abutment with a compromised retentive form. Various mechanical and chemical surface treatment methods have been proposed to increase bonding strength of zirconia. Those are, tribochemical silica coating or the use of primer or resin cements containing 4-methacryloyloxyethyl trimellitate anhydride or 10-methacryloxydecyldihydrogenphosphate monomer [19-22].

Failure mode			
Cement	**A**	**B**	**C**
Premier	8	1	1
DentoTemp	7	2	1
Cem-Implant	8	1	1
ImProv	9	0	1
TempBond NE	6	3	1
Total	**38 (78%)**	**7 (14%)**	**5 (8%)**

Table 3: The failure modes of the cements and percentages

A). Cement remained in the intaglio surface of the coping,
B). Cement remained on both coping and abutment surfaces,
C). Cement remained on the abutment surface

With a higher percentage, cement failure occurred at the cement/abutment interface and the cement remained attached mostly to the intaglio surface of the zirconia coping (Table 3). The removal of the temporary cement from abutment surface and intaglio surfaces of the zirconia copings was easier than the removal of implant cements. If the remnants of those cements remain attached to the intaglio surface of the restorations then a misfit may be anticipated during recementation.

The base-catalyst ratio and mixing methods of cements may affect tensile bond strength [9,23-26]. Therefore, in this study, cements with auto mix syringe dispensers were selected to overcome these problems. Pure uniaxial tensile test has been performed to allow comparisons with previous studies. Depending on the results of this study, it may be assumed that the studied implant cements hereby, provided adequate retrievability and retention. On the other hand, the amount of retention required for retrievability is controversial. The tensile bond strength values of the studied methacrylate-based resin cements may provide guidance for a clinician when more retentive temporary cementation of zirconia copings onto zirconia abutments is desired.

There are a number of limitations in this study. The influence of additional factors, such as screw access hole filling materials, variations in cement viscosity, cement film thickness and abutment characteristics were not investigated. Another limitation of the study is the inability of accurately simulating the intraoral environment and physical conditions. These factors may also contribute to tensile bond strength values. Further studies on the tensile bond strength of the most commonly preferred implant cements onto zirconia copings and abutments with different surface treatments but also intraorally tried for final control should be conducted, although standardization of implant components are difficult for clinical studies.

Conclusion

Within the limitations of this study, the following conclusions were drawn:

1. Different implant cements resulted in different tensile bond strength values when used cementation of zirconia copings onto zirconia abutments.
2. Using Premier may contribute to the retention of zirconia coping scemented onto zirconia abutments with compromised retentive form.

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